The FORD Program Accelerates Development of Hybrid Configurations

In December 1993, Ford Motor Company began its cost-shared, five and a half-year Hybrid Propulsion Systems Development Program. The objective of Ford's contract with the U.S. Department of Energy (DOE) is to develop and demonstrate a production-feasible hybrid propulsion system in a vehicle that incorporates advanced propulsion, electronic controls, and energy storage technologies, while meeting market requirements for cost, safety, and performance.

Hybrid Configurations Are Selected as Part of a Comprehensive System

Ford has identified two parallel hybrid propulsion system configurations that promise to meet the conflicting goals of low fuel consumption and tailpipe emissions, as well as low cost. The Low Storage Requirement (LSR) hybrid uses a small electric drive system (motor/inverter/battery) along with a newly developed, state-of-the-art compression-ignition, direct-injection (CIDI) diesel engine installed in a light weight vehicle platform. The LSR has an energy storage capacity of only 0.4kWh. This results in greatly reduced weight, size, and cost for the electric drive system. The power is routed through the transmission to the front wheels of the vehicle. In the LSR configuration, the battery energy augments the engine in peak power requirement situations such as acceleration and hill climbing.

The Post-Transmission Hybrid (PTH) features an electric traction motor permanently connected to the wheels through a transfer case. It utilizes a much larger battery pack: approximately 2.0 kWh. The larger energy storage capacity will allow greater flexibility in the control strategy and potentially valuable electric-only driving range. The electric motor launches the vehicle when the engine is shut down, captures regenerative breaking energy during deceleration, and can augment the engine during wide-open-throttle acceleration. The term "post-transmission" refers to the point at which the electric drive system's power assist enters the drive train – downstream of the transmission.

Hybridization of the powertrain, alone, will not result in achieving twice the fuel economy of a comparable conventional vehicle. Hybridization must be part of comprehensive vehicle system development for meeting this goal. Ford has developed a lightweight prototype vehicle called the P2000, as well as an efficient hybrid drivetrain incorporating the Direct-Injection Aluminum Throughbolt Accessory (DIATA) engine to meet the aggressive fuel economy goal.

Ford teamed with more than 60 Tier I suppliers to develop the P2000.

DOE progress in HEV research and development is described in this series of fact sheets

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What Are the Successes to Date?

P2000. The P2000, co-developed with Milford Fabricating Company, is a fully functional prototype vehicle, comparable in size but weighing 40% less than a Ford Taurus. Ford estimates that the conventional (non-hybrid) P2000 will get 63 mpg. In the standard configuration, the P2000 weighs 2000 lbs. and contains only about 500 pounds of steel and other ferrous metal. Weight reduction is the single most important factor in advancing fuel economy in the P2000 and is achieved through extensive use of aluminum combined with strategic uses of magnesium, carbon fiber, and titanium. This vehicle will serve as the platform for the Low Storage Requirement (LSR) hybrid vehicle and will be equally applicable to conventional vehicles. Most of North America's largest aluminum companies are participating, as well as major engine designers.

DIATA Engine. Ford's DIATA engine is a sophisticated, compression-ignition direct-injection (CIDI) diesel engine. It has an all aluminum, through-bolted block and head, a turbocharger, and a high-pressure common-rail fuel injection system. Coupled with advanced systems that monitor driving conditions and adjust engine operation to match those conditions, the common-rail fuel system delivers to the HPU the amount of fuel warranted by conditions, thereby increasing the overall fuel economy of the vehicle. The integrated starter-alternator facilitates both rapid restarts and low emissions during cold starts and restarts.

Battery Energy Storage. Ford tested two lead-acid battery configurations as well as nickel metal hydride (NiMH) battery technology. Battery discharge and recharge characteristics and thermal management requirements were determined using modeling and bench top testing. In addition, battery size and location in the vehicle were optimized to provide as much interior volume as possible. The LSR strategy allows for the battery to be recharged, at opportune times, using only the engine and regenerative braking. This means that the battery would be at various States-of-Charge (SOC) with very little time at full SOC. Based on test results and on past experience, Ford recommended that the NiMH technology be the candidate battery for use in the HEV deliverable vehicle.

For additional information, contact:

Rogelio A. Sullivan
U.S. Department of Energy, EE-32
1000 Independence Avenue, SW
Washington, DC 20585
(202) 586-8042
rogelio.sullivan@ee.doe.gov

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